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(71) Applicant(s):
IPWireless Inc
(Incorporated in USA - Delaware)
1001 Bayhill Drive 2nd Floor, San Bruno,
California 94066, United States of America

(72) Inventor(s):
William John Jones
Joseph Chung Shing Cheung
Alan Edward Jones

(74) Agent and/or Address for Service:
Peter Hudson
InetIP, 121 Blackberry Lane, Four Marks,
ALTON, Hampshire, GU34 5DJ,
United Kingdom

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"Capacity analysis of TDD cell sharing underutilized FDD link," Dong Hoi Kim, Pyeong Jung Song and Chung Gu Kang, IEEE VTS 53rd Vehicular Technology Conference, 2001, volume 4 pages 3044- 3048, ISBN: 0 7803 6728 6
"TDD-CDMA Extension to FDD-CDMA Based third generation cellular system," G Povey, Harri Holma and Antti Toskala, IEEE 6th International conference on universal mobile.. 1997, volume 2, pages 813-817 ISBN: 0 7803 3777 8
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(continued on next page)

(54) Abstract Title: **TDD operation in a frequency division duplex band**

(57) TDD operation in a communication system operating in TDD mode in a frequency band allocated for FDD operation.
Time Division Duplex may be used in uplink and downlink mode in a first frequency band designated or normally used for FDD uplink communication, and in TDD downlink-only mode in a second frequency band designated or normally used for FDD downlink communication.
Common signalling may be applied in both frequency bands, and the different TDD bands may be managed flexibly as a single mobile communications resource. Operating TDD mode in a frequency band allocated for FDD operation involves increasing uplink capacity by increasing the allocation of uplink time slots in FDDD uplink spectrum.

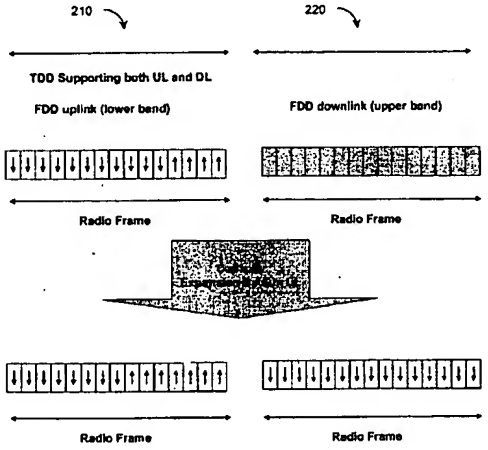

FIG. 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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Other: ONLINE: WPI, EPODOC, JAPIO, INSPEC

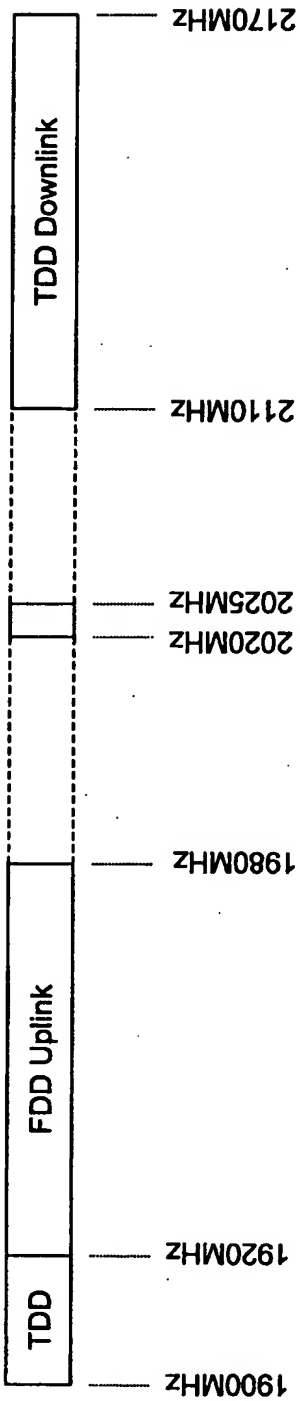
2170MHz
TDD Downlink
2110MHz
2025MHz
2020MHz
1980MHz
FDD Uplink
1920MHz
TDD
1900MHz

FIG. 1

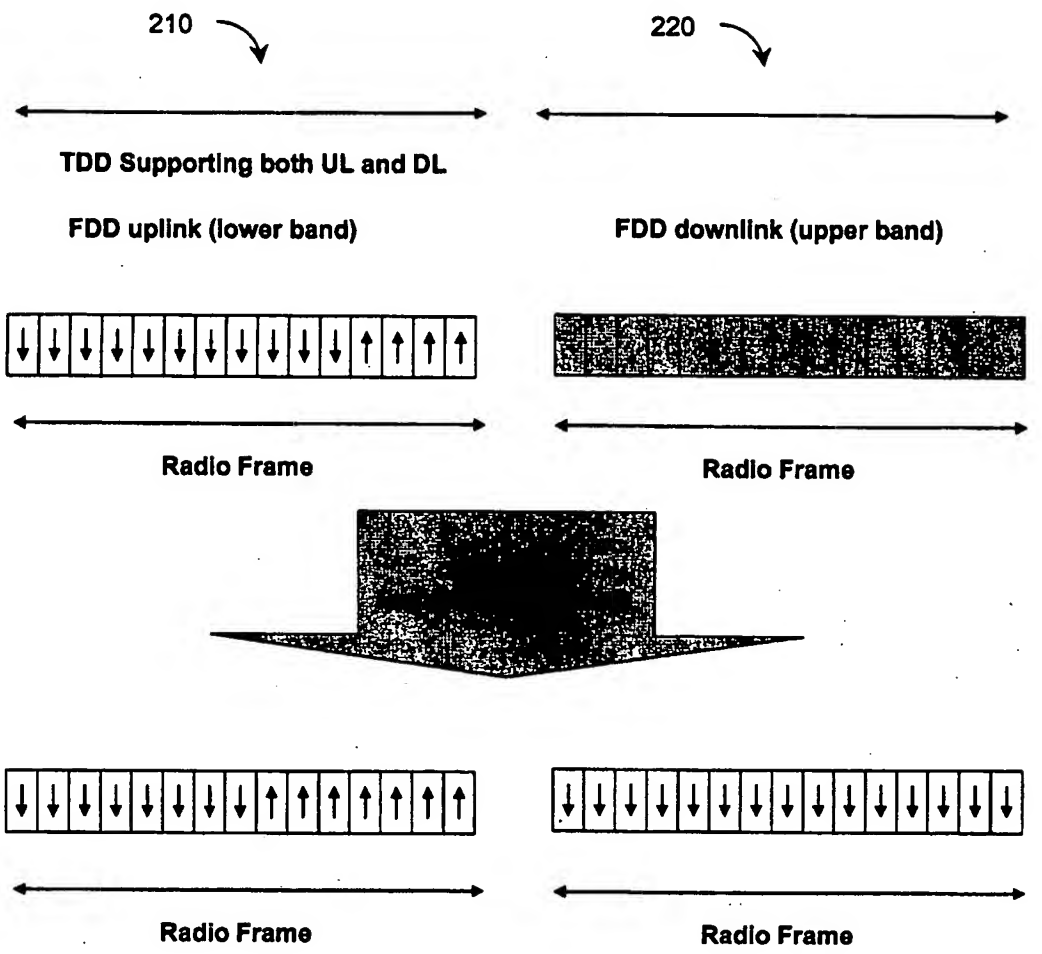
210
220
TDD Supporting both UL and DL
FDD uplink (lower band)
FDD downlink (upper band)
Radio Frame
Radio Frame
Radio Frame
Radio Frame

FIG. 2

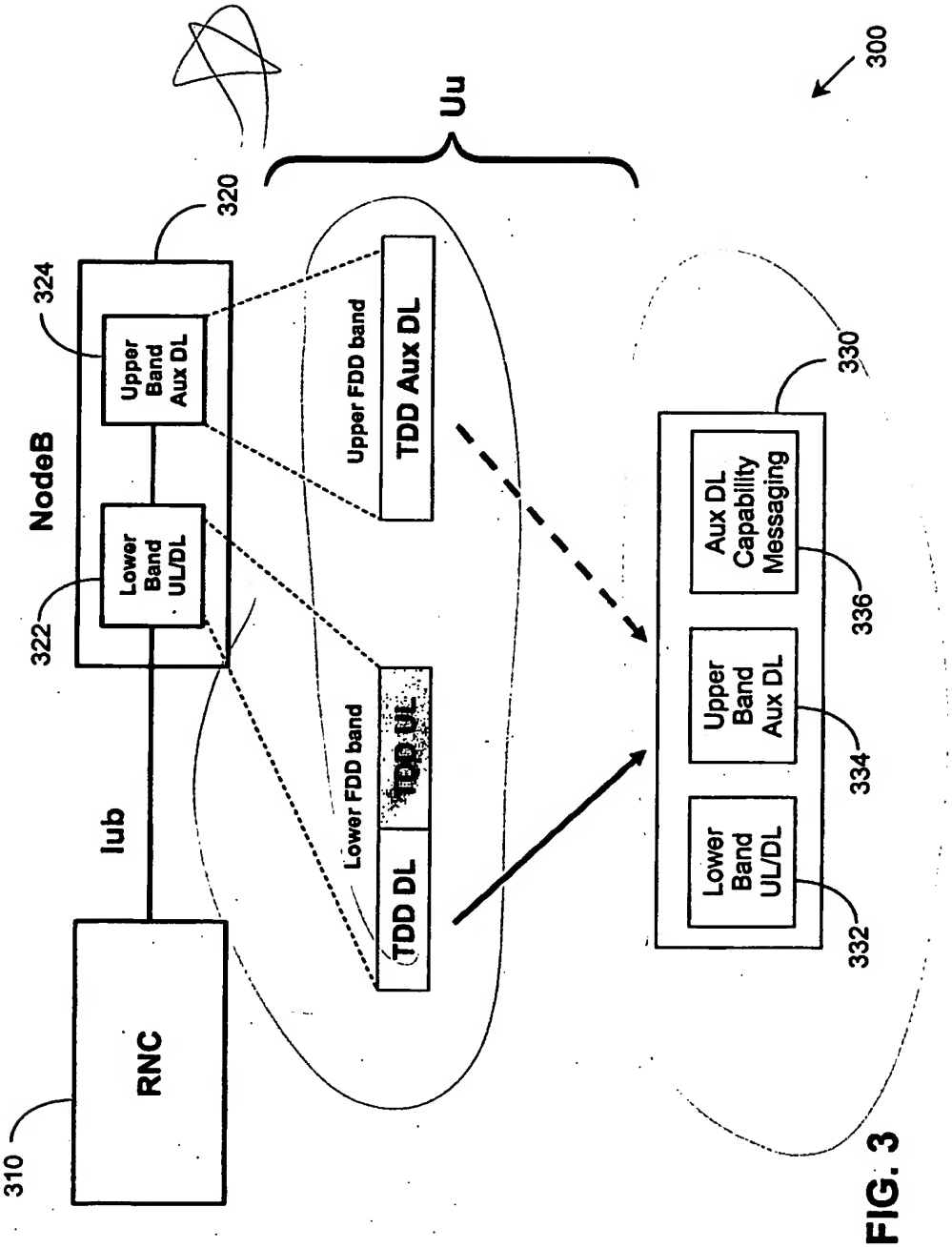
300
Uu
320
NodeB
324
Upper Band Aux DL
322
Lower Band UL/DL
Iub
RNC
310
Upper FDD band
TDD Aux DL
Lower FDD band
TDD UL
TDD DL
330
Aux DL Capability Messaging
336
Upper Band Aux DL
334
Lower Band UL/DL
332

FIG. 3

METHOD, BASE STATION AND MOBILE STATION FOR TDD OPERATION IN A COMMUNICATION SYSTEM

Field of the Invention

This invention relates to communication systems and particularly Time Division Duplex (TDD) operation in cellular communication systems.

Background of the Invention

In the field of this invention it is known that first and second generation cellular standards all use "Frequency Division Duplex" (FDD) in which there are separate downlink (base station to mobile) and uplink (mobile to base station) frequency allocations. These allocations are separated by a "duplex spacing" to prevent interference between the simultaneous transmission and reception taking place at both the base station and mobile. FDD allocations are typically termed "paired spectrum".

"Time Division Duplex" (TDD) is used in more recent standards, such as "3rd Generation Partnership Project" (3GPP) "Time Division - Code Division Multiple Access" (TD-CDMA) and 3GPP "Time Division - Synchronous Code Division Multiple Access" (TD-SCDMA). In TDD systems, transmission and reception takes place alternately in time on the same frequency. TDD is very well suited for

packet data communication where uplink and downlink capacity can easily be adjusted to meet subscriber traffic profile.

TDD is not used in FDD bands, because of interference concerns. TDD can operate in the mobile transmit (uplink) portion of a FDD band without detrimental interference. The allocation of TDD channels immediately adjacent to the FDD uplink channels in the "International Mobile Telecommunications 2000" (IMT-2000, International Telecommunication Union designated '3G' band) provides evidence of the feasibility of this. The frequency allocation for IMT-2000 is shown in FIG. 1.

However, operation of TDD in the downlink portion of an FDD band is problematic, because of adjacent channel interference from existing FDD base stations to the receivers of co-located or nearby TDD base stations, both of which typically transmit at higher power than the corresponding user terminals.

Consequently, where a wireless operator has an FDD spectrum allocation, TDD technology can normally only be operated in the FDD uplink part of the spectrum, leaving the FDD downlink spectrum unutilized and effectively 'wasted'.

A need therefore exists for an arrangement, method and unit for TDD operation in a communication system wherein the abovementioned disadvantage(s) may be alleviated.

Statement of Invention

In accordance with a first aspect of the present invention there is provided a method for TDD operation in a communication system as claimed in claim 1.

In accordance with a second aspect of the present invention there is provided a base station for TDD operation in a communication system as claimed in claim 8.

In accordance with a third aspect of the present invention there is provided a mobile station for TDD operation in a communication system as claimed in claim 15.

Brief Description of the Drawings

One method, base station and mobile station for TDD operation in a communication system incorporating the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 shows a block schematic illustration of IMT-2000 frequency allocation;

FIG. 2 shows a block schematic illustration of TDD with auxiliary downlink utilization; and

FIG. 3 shows a block schematic illustration of system architecture of TDD with auxiliary downlink.

Description of Preferred Embodiment(s)

The present invention is based on the realisation by the inventors that it is possible to:

- Enable operation of TDD technology in a band allocated as paired spectrum for FDD
- Provide the ability to use the FDD downlink spectrum effectively to provide capacity and therefore avoid wastage. This is referred to as an auxiliary TDD downlink channel.
- Avoid detrimental interference in operation of TDD in the FDD downlink spectrum.
- Remove the fixed duplex frequency separation requirement.

An example of TDD operation with auxiliary downlink is shown in FIG. 2. As illustrated, standard TDD operates in the uplink FDD spectrum (210) while the auxiliary downlink operates in the downlink FDD spectrum (220). In the illustration, an example of a 15-time slot frame structure is shown. An upward pointing arrow in a radio frame denotes an uplink time slot, and a downward pointing arrow denotes a downlink time slot. As can be seen, system capacity is expanded by use of the auxiliary downlink.

FIG. 3 shows the basic architecture of a 3GPP cellular communication system 300 incorporating the present invention. As illustrated, a NodeB (or base station) 310 is controlled (over the 'Iub' interface) by a Radio Network Controller (RNC) 320 and communicates over the Uu radio interface with User Equipment (UE or mobile terminal) 330.

It will be understood that in other respects the system 300 operates in accordance with relevant 3GPP Technical Specifications (available at the website http://www.3gpp.org), and need not be described in further detail herein. However, as will be explained further below, for the NodeB 320 the following is to be noted that the base station (NodeB) includes a lower band logical unit 322 and an upper band logical unit 324 and operates in both the upper (FDD downlink) and lower (FDD uplink) bands simultaneously, under the control of the RNC 310.

The lower band logical unit 322 supports normal TDD operation, where the radio resource is divided into time slots.

The upper band logical unit 324 supports auxiliary downlink operation. This logical unit supports downlink operation only. The radio resource is divided into time slots.

In the system of FIG. 3, three types of UE 330 can be supported:

1. Single frequency standard TDD UE (not shown):
   This is the standard TDD UE where both uplink and downlink operate on a single frequency. This type of UE will operate by communicating with the lower band logical unit in the NodeB.

2. Single instantaneous frequency UE (not shown):
   This type of UE is able to tune to two different frequencies (the lower and upper FDD bands) in the same TDD frame under the control of the network. The UE operates uplink transmission in the lower FDD band. The UE can operate in either the standard TDD downlink (lower FDD band) or auxiliary downlink (upper FDD band) under the control of the network.

3. Dual simultaneous frequency UE 330:
   This type of UE has a lower band UL/DL logical unit 332, an upper 'Aux DL' logical unit 334 and an 'Aux DL' Capability Messaging logical unit 336, and is able to simultaneously tune to both the lower and upper FDD bands. The UE operates uplink transmission in the lower FDD band. The UE operates standard TDD downlink (lower FDD band) and auxiliary downlink (upper FDD band) under the control of the network. With dual simultaneous frequency capability the UE is able to operate with increased downlink capacity.

In operation of the system of FIG. 3, the auxiliary downlink ('Aux DL') capability allows an inherently TDD technology to efficiently utilize the FDD downlink band, avoiding wastage of spectrum, and the downlink resource in the lower and upper bands is treated as a combined

'single pool' resource, which can be allocated to users according to demand. The NodeB 320 provides common signalling for both TDD frequencies.

At any time, an individual UE that can support the 'Aux DL' mode of operation may be allocated downlink capacity in the lower band or upper band or both.

UE's and NodeB's exchange 'Aux DL' capability messages, such that the NodeB's and UE's with and without the 'Aux DL' feature can co-exist in the network and each operate to the best of their respective abilities.

A UE that does not support auxiliary downlink, e.g., a roaming UE from another TDD network, is compatible with the auxiliary downlink architecture by operating in standard TDD mode in lower band. In this case, the auxiliary downlink feature is transparent to the UE.

While the Auxiliary Downlink increases the total downlink capacity, it also enables uplink capacity to be increased, as additional timeslots can be allocated in the lower TDD band to uplink traffic channels.

The separation of the lower and upper band is not restricted by the standard FDD duplex frequency separation. The UE is instructed by the network to tune to the correct frequency for the auxiliary downlink. At the network level the auxiliary downlink in the upper band can even be adjacent to the lower band (even though the UE may be required to operate only on one downlink

frequency at one time to minimize the receive filtering requirements). This effectively allows the operator to deploy the proposed TDD technology in contiguous frequency allocation.

It will be understood that the arrangement, method and unit for TDD operation in a communication system described above provides the following advantages:

- Provides a flexible method to deploy a time division duplex architecture in frequency division duplex spectrum.
- Allows flexible use of system capacity by adjusting the uplink and downlink capacity split.
- Removes previous FDD duplex restrictions.

Claim(s)

1. A method for TDD operation in a communication system, comprising:

operating in TDD mode in a frequency band allocated for FDD operation.

2. The method of claim 1 wherein the step of operating in TDD mode comprises: operating in TDD uplink and downlink mode in a first frequency band allocated for FDD uplink communication, and operating in TDD downlink-only mode in a second frequency band allocated for FDD downlink communication.

3. The method of claim 2 further comprising employing common signalling for the first and second frequency bands.

4. The method of claim 1, 2 or 3 further comprising messaging between a network and a mobile station of the system to establish whether the mobile station is capable of operating in TDD mode in a frequency band allocated for FDD operation and accordingly communicating between the network and the mobile station.

5. The method of any preceding claim further comprising managing a plurality of TDD frequencies as a single resource.

6. The method of any preceding claim wherein the step of operating in TDD mode in a frequency band allocated

for FDD operation comprises increasing uplink capacity by increasing the allocation of uplink time slots in FDD uplink spectrum.

7. The method of any preceding claim wherein the system comprises a 3GPP system.

8. A base station for TDD operation in a communication system, the base station comprising:

means for operating in TDD mode in a frequency band allocated for FDD operation.

9. The base station of claim 8 wherein the means for operating in TDD mode comprises:

means for operating in TDD uplink and downlink mode in a first frequency band allocated for FDD uplink communication; and

means for operating in downlink-only mode in a second frequency band allocated for FDD downlink communication.

10. The base station of claim 9 further comprising means for common signalling for the first and second frequency bands.

11. The base station of claim 8, 9 or 10 further comprising means for messaging with a mobile station of the system to establish whether the mobile station is capable of operating in TDD mode in a frequency band allocated for FDD operation and accordingly communicating with the mobile station.

12. The base station of any one of claims 8-11 further comprising means for managing a plurality of TDD frequencies as a single resource.

13. The base station of any one of claims 8-12 wherein the means for operating in TDD mode in a frequency band

allocated for FDD operation comprises means for increasing uplink capacity by increasing the allocation of uplink time slots in FDD uplink spectrum.

14. The base station of any one claims 8-13 wherein the system comprises a 3GPP system and the base station comprises a NodeB.

15. A mobile station station for TDD operation in a communication system, the mobile station comprising:

means for operating in TDD mode in a frequency band allocated for FDD operation.

16. The mobile station of claim 15 wherein the means for operating in TDD mode comprises:

means for operating in TDD uplink and downlink mode in a first frequency band allocated for FDD uplink communication; and

means for operating in downlink-only mode in a second frequency band allocated for FDD downlink communication.

17. The mobile station of claim 16 further comprising means for common signalling for the first and second frequency bands.

18. The mobile station of claim 14, 15 or 16 further comprising means for messaging with a network of the system to establish whether the mobile station is capable of operating in TDD mode in a frequency band allocated for FDD operation and accordingly communicating with the network.

19. The mobile station of claim 15 wherein means for operating in the first frequency band and means for operating in the second frequency band are arranged to operate simultaneously.

20. The mobile station of any one of claims 15-19 wherein the means for operating in TDD mode in a frequency band allocated for FDD operation comprises means for increasing uplink capacity by increasing the allocation of uplink time slots in FDD uplink spectrum.

21. The mobile station of any one claims 15-20 wherein the system comprises a 3GPP system and the base station comprises User Equipment.

22. A method, for TDD operation in a communication system, substantially as hereinbefore described with reference to the accompanying drawings.

23. A base station, for TDD operation in a communication system, substantially as hereinbefore described with reference to the accompanying drawings.

24. A mobile station, for TDD operation in a communication system, substantially as hereinbefore described with reference to the accompanying drawings.

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Application No: GB 0303079.8 **Examiner:** Robert Shorthouse
Claims searched: 1-24 **Date of search:** 2 September 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 2, 5-9, 13-16, 21, 22 at least	WO 02/058270 A2 (RAZE) See abstract and page 5 line 34- page 6 line 29
X	1, 7, 8, 14 15, 21	US 2002/0098821 A1 (STRUHSAKER) See abstract
X	1, 6-8, 13-15, 20, 21 at least	"Capacity analysis of TDD cell sharing underutilized FDD link," Dong Hoi Kim, Pyeong Jung Song and Chung Gu Kang, IEEE VTS 53rd Vehicular Technology Conference, 2001, volume 4 pages 3044- 3048, ISBN: 0 7803 6728 6
X	1, 7, 8, 14 15, 21	"TDD-CDMA Extension to FDD-CDMA Based third generation cellular system," G Povey, Harri Holma and Antti Toskala, IEEE 6th International conference on universal mobile.. 1997, volume 2, pages 813-817 ISBN: 0 7803 3777 8
X	1, 7, 8, 14 15, 21	" Frequency selection strategies for Hybrid TDD/FDD-CDMA Cellular networks", W Wong and E Sousa, IEEE Conference, 1999, Volumne 2, pages 1152-1156, ISBN: 0 7803 5284 X

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

H4L

Worldwide search of patent documents classified in the following areas of the IPC[7]:

H04Q, H04J

The following online and other databases have been used in the preparation of this search report:

WPI, EPODOC, JAPIO, INSPEC